UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
OREGON OPERATIONS OFFICE
805 SW Broadway, Suite 500
Portland, Oregon 97205

April 11, 2008

Mr. Jim McKenna
Port of Portland & Co-Chairman, Lower Willamette Group
121 NW Everett
Portland, Oregon 97209

Mr. Robert Wyatt
Northwest Natural & Co-Chairman, Lower Willamette Group
220 Northwest Second Avenue
Portland, Oregon 97209

Re: Portland Harbor Superfund Site; Administrative Order on Consent for Remedial Investigation and Feasibility Study; Docket No. CERCLA-10-2001-0240. Toxicity Reference Values for the Baseline Ecological Risk Assessment

Dear Messrs. Wyatt and McKenna:

As you are aware, EPA developed a Problem Formulation for the Baseline Ecological Risk Assessment at the Portland Harbor Site (Problem Formulation). The attached document includes recommended TRVs for the Portland Harbor baseline ecological risk assessment (BERA). These TRVs should be considered the effects assessment portion of the Problem Formulation.

TRVs have been developed for water, sediment and the dietary assessment of fish and wildlife. A brief summary of EPA's methodology for developing TRVs along with a series of tables presenting the recommended TRVs are included. Tissue-residue TRVs are still under development and will be transmitted to the Lower Willamette Group (LWG) under separate cover.

EPA and the LWG have committed to resolving all issues related to the draft remedial investigation and baseline risk assessment reports by June 1, 2008. A key element of the BERA is selection of TRVs. EPA has carefully considered the LWG's position regarding TRVs in developing the set of recommended TRVs. EPA expects that the TRVs presented in the attached document will be used in the Portland Harbor baseline ecological risk assessment.

If you have any questions, please contact Chip Humphrey at (503) 326-2678 or Eric Blischke (503) 326-4006. All legal inquiries should be directed to Lori Cora at (206) 553-1115.

Sincerely,

Chip Humphrey
Eric Blischke
Remedial Project Managers

cc: Greg Ulirsch, ATSDR
Rob Neely, NOAA
Ted Buerger, US Fish and Wildlife Service
Preston Sleeger, Department of Interior
Jim Anderson, DEQ
Kurt Burkholder, Oregon DOJ
David Farrer, Oregon Environmental Health Assessment Program
Rick Keppler, Oregon Department of Fish and Wildlife
Michael Karnosh, Confederated Tribes of Grand Ronde
Tom Downey, Confederated Tribes of Siletz
Audie Huber, Confederated Tribes of Umatilla
Brian Cunninghame, Confederated Tribes of Warm Springs
Erin Madden, Nez Perce Tribe
Rose Longoria, Confederated Tribes of Yakama Nation

Toxicity Reference Values for Portland Harbor Baseline Ecological Risk Assessment

Provisional Toxicity Reference Values (TRVs) for Portland Harbor were initially developed and presented in the 2004 TRV Technical Memorandum (LWG [Lower Willamette Group] 2004); subsequent discussions with EPA led to the use of revised provisional TRVs (for exposure pathways other than water) in the Preliminary Risk Evaluation (PRE) (LWG 2005). Further direction on TRVs was provided to LWG in EPA's comments on the PRE, and in discussions throughout 2006 in preparation for the Round 2 Report (R2R) including direction on TRVs for exposure to water). For the most part, EPA direction on the provisional TRVs was followed for the screening-level risk evaluations in the Round 2 Report (see LWG 2007, attachments to Appendix G; for exceptions, see EPA 2008a [the EPA-updated SLERA]).

A comprehensive set of TRVs will be required for use in the Baseline Ecological Risk Assessment (BERA). Initial recommendations for BERA TRVs were presented in Attachment G5 to Appendix G of the Round 2 Report. This report presents EPA's recommended TRVs for ecological receptors from exposure via all primary pathways, including water, sediment, diet, and tissue. The attached TRVs should be considered the effects assessment portion of the February 15, 2008 Problem Formulation for the Baseline Ecological Risk Assessment at the Portland Harbor Site.

To the extent possible, existing TRVs derived and compiled for the Portland Harbor site are recommended for use. However, some existing were intended to be only used for screening-level purposes (i.e., were "provisional"). Consequently, an updated set of BERA TRVs are required . In this report, TRVs are compiled only for chemicals of potential ecological concern (COPCs) that screened in based on the Round 2 Report (and as updated in EPA 2008a). In addition, TRVs with known or unresolved issues from earlier discussions between EPA and LWG have been revisited. In some of these cases, use of newer TRVs as proposed here meant that additional chemicals would screen back in; these are highlighted below, and retained for use in the BERA.

Recommended TRVs for water, sediment and the dietary assessment of fish and wildlife are presented below. A brief summary of EPA's methodology for developing TRVs is presented along with a series of tables presenting the recommended TRVs. Because EPA is still in the process of reviewing tissue-residue TRVs, tissue-residue TRVs are not included.

WATER

Recommended TRVs for protection of aquatic receptors from exposure to COPCs in water are presented in Table 1. TRVs are only presented for COPCs retained from the Round 2 Report SLERA (and as updated in EPA 2008a). Many of these TRVs are identical to the ecological screening values for water (Eco-SLs) compiled in Attachment G3 to Appendix G of the Round 2 Report. Upon our review, we found that the Attachment G3 values generally followed the same selection hierarchy previously agreed upon by EPA and LWG:

1. Lowest of national ambient water quality criteria (AWQC) or state water quality standards (WQS) from either existing Table 20 values or proposed WQS in Tables 33A or 33B.

2. Tier II values from Suter and Tsao (1996).
3. Individual polycyclic aromatic hydrocarbon (PAH) chronic TRVs from EPA 2003.
4. Canadian water quality guidelines.
5. More protective of Oregon Department of Environmental Quality (DEQ) acute guidance values or Tier II acute values, divided by a safety factor of 50.
6. Literature-derived values.

The primary difference between the hierarchy applied to develop the TRVs presented in Table 1 and the hierarchy applied in the Round 2 Report is in use of Table 33C values from DEQ's proposed WQS. Table 33C values are "guidance values" for application of Oregon's Narrative Toxics Criteria, and are not necessarily risk-based, or provide equivalent levels of protection to aquatic life as do AWQC. In EPA's review of draft Eco-SLs in 2006, however, Table 33C values were sometimes recommended as if they were equivalent to Table 33A and 33B values in the first step of the selection hierarchy, when in fact they should more appropriately be considered in step 5 of the hierarchy. Therefore, our TRV review focused on evaluating alternatives for the Table 33C values included in Attachment G3. For the most part, Tier II or other more highly ranked TRVs could be found, or the Table 33C values were already equivalent to a more highly ranked TRV.

Table 1 also includes TRVs for protection of aquatic life from total petroleum hydrocarbons (TPH). EPA previously recommended TRVs for TPHs (March 24, 2006 memorandum to LWG) that were based on approaches used in Alaska and Washington; these TRVs were 114 µg/L for gasoline range hydrocarbons ($C_6 – C_{10}$), and 0.014 µg/L for diesel range hydrocarbons ($C_{10} – C_{25}$). The Alaska values were derived in part from an equation (Veith et al. 1979) relating bioconcentration factors (BCF) with octanol-water partition coefficients (K_{OW}). LWG elected not to use these TRVs in the R2R owing to concerns over the reliability of these values and because they were to some extent based on narrative criteria. Therefore, EPA is proposing to use an updated approach for derivation of TRVs for selected TPH fractions. This updated approach was prepared by Burt Shephard and Mike Poulsen for use in Oregon (Appendix A). The updated TRVs use a parabolic relationship between BCF and K_{OW} (Bintein et al. 1993) as part of the derivation methodology, as opposed to the linear relationship between BCF and K_{OW} previously used (Veith et al. 1979). This approach largely eliminates the overprediction of the bioaccumulation of higher molecular weight TPH compounds of the previous methodology. The current approach is also supported by some empirical aquatic toxicity data for gasoline, where the studies were performed in zero head space exposure chambers that precluded volatilization of the TPH out of the exposure chamber. The methodology is an application of the "hydrocarbon block method" as described by CONCAWE (1996) that develops ecological protection values for "blocks" or carbon chain length ranges of hydrocarbons rather than chemical-specific values. Therefore, TRVs presented in Table 1 include values for 4 different carbon chain length ranges, as defined by the State of Oregon, for aliphatic hydrocarbons (from C_5 up to C_{12}), and one range for aromatic hydrocarbons ($C_8 – C_{12}$). No TRVs were developed for hydrocarbons larger than C_{12} because reliable toxicity data were not available, or no chronic toxicity is predicted by the model at or below maximum levels of water solubility for higher molecular weight hydrocarbons. For additional details regarding derivation of these TRVs, see Appendix A.

All Table 33C values from Attachment G3 were checked for alternatives, even if the chemicals screened out in the SLERA. For the most part, these chemicals would still screen out, even after identifying suitable alternative TRVs (analysis not shown). However, alternative TRVs for acrolein and chloroform were lower than the maximum water concentrations identified in the Round 2 Report; therefore, revised TRVs are included in Table 1, and these chemicals should be evaluated in the BERA.

Most of the TRVs for COPCs in Table 1 are now either based on AWQC, chronic PAH values from EPA (2003), or Tier II values from Suter and Tsao (1996). The basis of any TRV not from this list of sources was re-checked against the hierarchy, and alternatives from the literature were considered, particularly from the water quality criteria compilation of MacDonald et al. (1999).

DIETARY PATHWAYS

FISH

Recommended TRVs for protection of fish via exposure to COPCs from the dietary pathway are presented in Table 2 for all chemicals retained from the SLERA (EPA 2008a). Dietary TRVs are included for PCBs and DDT because they were retained through the screening process even though EPA's Problem Formulation for the Ecological Risk Assessment recommends that only PAHs and regulated metals should be evaluated through the dietary pathway for fish. These TRVs are primarily based on revised dietary TRVs for fish in Attachment G5 to Appendix G of the Round 2 Report. The technical basis of these revisions was evaluated for each COPC, and for the most part, EPA agrees with LWG's new interpretation of these studies. Therefore, most of the revised Attachment G5 TRVs are acceptable for use in the BERA.

The only exceptions are for TBT and mercury, for which EPA disagrees with LWG's interpretation of the no observed adverse effect level (NOAEL) and lowest observed adverse effect level (LOAEL) values obtained from the selected literature studies. Alternative values and their basis are presented in Table 2.

AVIAN AND MAMMALIAN WILDLIFE

Recommended TRVs for protection of avian and mammalian wildlife via exposure to COPCs from the dietary pathway are presented in Table 3 and Table 4, respectively. As indicated in previous TRV discussions between LWG and EPA in 2006, EPA recommends that TRVs be based on those presented in ecological soil screening level reports (Eco-SSLs; EPA 2005a,b,c,d,e, and 2007b,c,d,e,f) wherever possible. TRVs from the Eco-SSLs represent thorough and peer-reviewed evaluations of the wildlife toxicology literature, and are gaining wide acceptance for use in ecological risk assessments. The Round 2 Report concluded that TRVs derived from Eco-SSLs were not appropriate for us at the Portland Harbor site because the studies compiled for the Eco-SSLs sometimes include other exposure pathways besides purely dietary (e.g., gavage and drinking water). EPA acknowledges that this is the case. However, the reliability weighting scheme used in the Eco-SSLs did take this multiple pathway concern into account. Therefore, EPA still recommends that the Eco-SSL documents represent the best source of TRVs.

EPA also recognizes that the Eco-SSL-based TRVs were based on NOAELs, and are therefore specifically to be used only for screening-level risk evaluations. For the less conservative BERA, therefore, EPA derived corresponding LOAELs from the same datasets or studies used to derive NOAELs. Our approach to LOAEL derivation varied, depending on the number of available studies and the approach used in the Eco-SSL to derive the NOAEL for that chemical. For example, if a NOAEL was derived as geometric mean of available NOAELs, then a geometric mean of the corresponding LOAELs was used. If, instead, NOAELs were selected from a single (e.g., lowest appropriate) study, then a LOAEL was selected from the same study, if possible. Additional details for derivation of Eco-SSL-based TRVs are given in Tables 3 and 4.

Because Eco-SSL documents were not available for all Portland Harbor COPCs, we reviewed the basis of LWG-recommended TRVs from the Round 2 Report. Alternative values and their basis are presented, where appropriate, in Tables 3 and 4.

SEDIMENTS

Recommended TRVs for protection of benthic macroinvertebrates via exposure to COPCs in sediments are presented in Table 5. This list reflects those COPCs screened in during the SLERA sediment quality guideline (SQG) evaluation conducted by EPA (2008a). The SQGs provided in Table 5 represent the three types of SQGs that will be compared to bulk sediment concentrations for the BERA: consensus-based (Probable Effect Concentrations [PECs]), mechanistic-based (Equilibrium Partitioning [Eq-P]), and empirical (Probable Effect Levels [PELs] and Washington State Cleanup Screening Levels [CSLs]). In addition, SQGs selected from the Joint Source Control Strategy (JSCS; DEQ 2007) (Table 3-1, 07/16/07 revision, MacDonald PEC [or other SQV] column) are provided in Table 5.

Because three different empirical SQGs are presented, the single most appropriate SQG should be selected for any given chemical. Similar to the approach used in EPA's updated SLERA (EPA 2008a), the lowest or most protective SQG from the PEL and CSL (after considering carbon-normalization where appropriate) lists should be selected for each chemical. Given that JSCS values were primarily intended for use in screening-level evaluations and were compiled from multiple sources, SQGs should only be selected from the JSCS list if no other empirical SQGs are available for that chemical.

PEC (MacDonald et al. 2000) and CSL (Washington State Department of Ecology 1995) values were extracted from the Query Manager (QM) database (version 2.6, Portland Harbor Cat1Risk, October 2007 data update; sqc.dbf). The majority of PEL values were also extracted from QM (Smith et al. 1996); however Canadian sediment quality guidelines (CCME 2002) were used where Smith et al. did not provide PELs. EqP-based values were calculated using the following equation, per EPA guidance for derivation of equilibrium partitioning sediment benchmarks (ESB; EPA 2008b):

$$ESB_{oc} = K_{oc} * chronic\ water\ column\ TRV$$

where ESB_{oc} is the equilibrium partitioning sediment benchmark expressed on a sediment organic carbon normalized basis (i.e., ESBs are expressed in units of µg/kg organic carbon),

K_{oc} is the organic carbon:water partition coefficient, and the chronic water column TRV is one of the previously compiled, EPA-recommended chronic water TRVs (Table 1)[1]. Empirically derived K_{oc} values were obtained from the literature or calculated from octanol:water partition coefficients (K_{ow}), or from the literature, where empirically derived values were not available. In the case of multiple empirical K_{oc} values, the average was used.

Because the calculated ESBs are expressed on an organic carbon normalized basis, sediment contaminant concentrations (expressed on a dry weight basis) will need to be converted to µg contaminant/kg organic carbon (using the concurrent organic carbon data) prior to ESB comparison and risk characterization. The same step will have to be conducted for CSL values for all analytes except phenol, 2-methylphenol, 4-methylphenol, 2,4,-dimethylphenol, pentachlorophenol, benzyl alcohol, and benzoic acid (which are not expressed on an organic carbon normalized basis).

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[1] Table 1 does not include TRVs for all of the sediment COPCs. However, the hierarchical approach previously discussed was followed to select the remaining necessary TRVs, and the full list is presented in Table 5.

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Table 1. Acute and Chronic TRVs for Chemicals in Water from Round 2 Report and as Proposed for BERA

Chemical of Potential Concern[a]	R2R Acute Eco SL (µg/L)	R2R Chronic Eco SL (µg/L)	EPA Recommended TRVs Proposed for BERA			
			TRV Source[b]	Comments	Acute TRV (µg/L)	Chronic TRV (µg/L)
Metals						
Barium	110	4	Tier II	TRVs are based on total.	110	4
Cadmium	0.52	0.09	AWQC	TRVs are hardness-dependent and were adjusted using AWQC equations to correspond with a hardness of 25 mg/L calcium carbonate (estimate for the Lower Willamette River [LWR]). TRVs are based on dissolved fraction.	0.52	0.09
Copper	3.64	2.74	AWQC	TRVs are hardness-dependent and were adjusted using AWQC equations to correspond with a hardness of 25 mg/L calcium carbonate (estimate for the LWR). TRVs are based on dissolved fraction.	3.64	2.74
Lead	13.88	0.54	AWQC	TRVs are hardness-dependent and were adjusted using AWQC equations to correspond with a hardness of 25 mg/L calcium carbonate (estimate for the LWR). TRVs are based on dissolved fraction.	13.88	0.54
Nickel	144.9	16.1	AWQC	TRVs are hardness-dependent and were adjusted using AWQC equations to correspond with a hardness of 25 mg/L calcium carbonate (estimate for the LWR). TRVs are based on dissolved fraction.	144.9	16.1
Sodium	6,800,000	680,000	LCV	TRVs are based on total. Acute TRV was derived by multiplying the chronic TRV by 10.	6,800,000	680,000
Vanadium	280	20	Tier II	TRVs are based on total.	280	20
Zinc	36.2	36.5	AWQC	TRVs are hardness-dependent and were adjusted using AWQC equations to correspond with a hardness of 25 mg/L calcium carbonate (estimate for the LWR). TRVs are based on dissolved fraction.	36.2	36.5

Table 1. Acute and Chronic TRVs for Chemicals in Water from Round 2 Report and as Proposed for BERA (Continued)

Chemical of Potential Concern[a]	R2R Acute Eco SL (µg/L)	R2R Chronic Eco SL (µg/L)	EPA Recommended TRVs Proposed for BERA			
			TRV Source[b]	Comments	Acute TRV (µg/L)	Chronic TRV (µg/L)
PAHs						
2-Methylnaphthalene	37	2.1	Tier II	The TRVs for 1-methynapthalene were used as a surrogate.	37	2.1
Acenaphthene	80	23	Tier II	The acute and chronic TRVs are the EPA calculated final acute value (FAV) and final chronic value (FCV), respectively, for sediment quality guideline development (EPA 1993).	80	23
Acenaphthylene	NA	306.9	EPA (2003)	EPA (2003) does not calculate PAH-specific acute values based on narcosis model predictions as they did for the chronic values.	NA	306.9
Anthracene	13	0.73	Tier II		13	0.73
Benzo(a)anthracene	0.49	0.027	Tier II		0.49	0.027
Benzo(a)pyrene	0.24	0.014	Tier II		0.24	0.014
Benzo(b)fluoranthene	NA	0.6774	EPA (2003)	EPA (2003) does not calculate PAH-specific acute values based on narcosis model predictions as they did for the chronic values.	NA	0.6774
Benzo(g,h,i)perylene	NA	0.4391	EPA (2003)	EPA (2003) does not calculate PAH-specific acute values based on narcosis model predictions as they did for the chronic values.	NA	0.4391
Benzo(k)fluoranthene	NA	0.6415	EPA (2003)	EPA (2003) does not calculate PAH-specific acute values based on narcosis model predictions as they did for the chronic values.	NA	0.6415
Chrysene	NA	2.042	EPA (2003)	EPA (2003) does not calculate PAH-specific acute values based on narcosis model predictions as they did for the chronic values.	NA	2.042

Table 1. Acute and Chronic TRVs for Chemicals in Water from Round 2 Report and as Proposed for BERA (Continued)

Chemical of Potential Concern[a]	R2R Acute Eco SL (µg/L)	R2R Chronic Eco SL (µg/L)	EPA Recommended TRVs Proposed for BERA			
			TRV Source[b]	Comments	Acute TRV (µg/L)	Chronic TRV (µg/L)
Dibenz(a,h)anthracene	NA	0.2825	EPA (2003)	EPA (2003) does not calculate PAH-specific acute values based on narcosis model predictions as they did for the chronic values.	NA	0.2825
Fluoranthene	33.6	6.16	Tier II	The acute and chronic TRVs are the EPA calculated final acute value (FAV) and final chronic value (FCV), respectively, for sediment quality guideline development (EPA 1993).	33.6	6.16
Fluorene	70	3.9	Tier II	TRVs as calculated for OSWER (1996).	70	3.9
Indeno(1,2,3-cd)pyrene	NA	0.275	EPA (2003)	EPA (2003) does not calculate PAH-specific acute values based on narcosis model predictions as they did for the chronic values.	NA	0.275
Naphthalene	190	12	Tier II		190	12
Phenanthrene	30	6.3	Tier II	The acute and chronic TRVs are the EPA calculated final acute value (FAV) and final chronic value (FCV), respectively, for sediment quality guideline development (EPA 1993).	30	6.3
Pyrene	NA	10.11	EPA (2003)	EPA (2003) does not calculate PAH-specific acute values based on narcosis model predictions as they did for the chronic values.	NA	10.11
SVOCs						
1,2-Dichlorobenzene	260	14	Tier II		260	14
1,4-Dichlorobenzene	180	15	Tier II		180	15
Dioxins/Furans						
Dibenzofuran	66	3.7	Tier II		66	3.7

Table 1. Acute and Chronic TRVs for Chemicals in Water from Round 2 Report and as Proposed for BERA (Continued)

Chemical of Potential Concern[a]	R2R Acute Eco SL (µg/L)	R2R Chronic Eco SL (µg/L)	EPA Recommended TRVs Proposed for BERA			
			TRV Source[b]	Comments	Acute TRV (µg/L)	Chronic TRV (µg/L)
Phenols						
4-chloro-3-methylphenol	30	0.60	MacDonald et al. 1999; RI DEM	Chronic TRV was derived by dividing the acute TRV by 50. MacDonald et al. 1999 presents acute and chronic criteria for 4-chloro-2-methylphenol; criteria selected here are from Rhode Island.	15	0.32
PCBs						
Total PCBs	2	0.014[c]	DEQ 33A; and AWQC (chronic)	TRVs for total PCBs applies to the sum of all homologs, sum of Aroclors, or sum of congeners.	2	0.014
Pesticides						
2,4'-DDD	1.1	0.001	AWQC	AWQC for 4,4'-DDT applies to 2,4'-DDD.	1.1	0.001
2,4'-DDT	1.1	0.001	AWQC	AWQC for 4,4'-DDT applies to 2,4'-DDT.	1.1	0.001
4,4'-DDD	1.1	0.001	AWQC	AWQC for 4,4'-DDT applies to 4,4'-DDD.	1.1	0.001
4,4'-DDE	1.1	0.001	AWQC	AWQC for 4,4'-DDT applies to 4,4'-DDE.	1.1	0.001
4,4'-DDT	1.1	0.001	AWQC		1.1	0.001
Total DDT	1.1	0.001	AWQC	AWQC for 4,4'-DDT applies to total DDTs.	1.1	0.001
Herbicides						
Dalapon	NA	2	ECOTOX	Can not confirm R2R chronic value from LT50 values in George et al. (1982) as reported in ECOTOX. Proposed alternatives based on a 48-hr EC50 for *Daphnia pulex* as the lowest acute value for a freshwater species in ECOTOX using a standard test type. Chronic and acute TRVs were derived by dividing this EC50 by 50 and 2, respectively.	5,500	220
Silvex™	125	5.0	ECOTOX	Chronic and acute TRVs were derived by dividing the LC50 reported by ECOTOX by 50 and 2, respectively.	125	5.0
VOCs						
1,1-Dichloroethene	450	25	Tier II		450	25

Table 1. Acute and Chronic TRVs for Chemicals in Water from Round 2 Report and as Proposed for BERA (Continued)

Chemical of Potential Concern[a]	R2R Acute Eco SL (µg/L)	R2R Chronic Eco SL (µg/L)	EPA Recommended TRVs Proposed for BERA			
			TRV Source[b]	Comments	Acute TRV (µg/L)	Chronic TRV (µg/L)
cis-1,2-Dichloroethene	11,600	590	Tier II	The acute TRV for dichloroethylenes was applied to both cis- and trans-congeners.	1,100	590
1,2,4-Trimethylbenzene	130	7.3	Tier II	TRVs for ethylbenzene were used as a surrogate.	130	7.3
1,3,5-Trimethylbenzene	130	7.3	Tier II	TRVs for ethylbenzene were used as a surrogate.	130	7.3
Acetone	28,000	1,500	Tier II		28,000	1,500
Acrolein	68	21	MacDonald et al. 1999	Lowest relevant criteria from MacDonald et al. 1999 are from Rhode Island DEM. Use of RI numbers would screen acrolein back in.	2.9	0.06
Benzene	2,300	130	Tier II		2,300	130
Carbon disulfide	17	0.92	Tier II		17	0.92
Chlorobenzene	250	50	Tier II		1100	64
Chloroethane	830	47	Tier II	TRVs for 1,1-dichloroethane were used as a surrogate.	830	47
Chloroform	28,000	1,240	Tier II	If Tier II values used instead of DEQ 33C, chloroform would screen back in.	490	28
Ethylbenzene	32,000	7.3	Tier II	Tier II used for both acute and chronic.	130	7.3
Isopropylbenzene (1-Methylethylbenzene)	130	7.3	Tier II	TRVs for ethylbenzene were used as a surrogate.	130	7.3
Toluene	17,500	9.8	Tier II	Acute value of 17,500 approved by EPA in 9/15/06 memo, but Tier II preferred for both so acute is not a 33C value.	120	9.8
Trichloroethene	45,000	21,900	Tier II	Tier II preferred over 33C values.	440	47
Vinyl chloride	97,000	3,880	Brown et al. (1977)	Chronic and acute TRVs were derived by dividing the LC100 reported by Brown et al. (1977) by 50 and 2, respectively.	97,000	3,880
m,p-Xylene	1,200	66.67	EPA (2006b)	TRVs for m-xylene were used.	1,200	66.67
o-Xylene	230	13	Tier II	TRVs for xylene were used as a surrogate.	230	13
Total Xylene	230	13	Tier II	TRVs for xylene were used as a surrogate.	230	13

Table 1. Acute and Chronic TRVs for Chemicals in Water from Round 2 Report and as Proposed for BERA (Continued)

Chemical of Potential Concern[a]	R2R Acute Eco SL (µg/L)	R2R Chronic Eco SL (µg/L)	EPA Recommended TRVs Proposed for BERA			
			TRV Source[b]	Comments	Acute TRV (µg/L)	Chronic TRV (µg/L)
Cyanide						
Cyanide	22	5.2	AWQC	Criteria are expressed as free cyanide, but total cyanide can be used to conservatively estimate contributions by easily dissociable metallo-cyanide complexes.	22	5.2
Perchlorate						
Perchlorate	NA	18	Dean et al. (2004)	TRVs developed using methods for derivation of AWQC considered more appropriate for BERA	20,000	9,300
Total Petroleum Hydrocarbons						
Aliphatics: C_5 - C_6	NA	NA	CONCAWE (1996)	Basic approach from CONCAWE (1996); specific TRV calculations and rationale given in Appendix A.	NA	128
Aliphatics: C_6 - C_8	NA	NA	CONCAWE (1996)	Basic approach from CONCAWE (1996); specific TRV calculations and rationale given in Appendix A.	NA	54
Aliphatics: C_8 - C_{10}	NA	NA	CONCAWE (1996)	Basic approach from CONCAWE (1996); specific TRV calculations and rationale given in Appendix A.	NA	9.5
Aliphatics: C_{10} - C_{12}	NA	NA	CONCAWE (1996)	Basic approach from CONCAWE (1996); specific TRV calculations and rationale given in Appendix A.	NA	2.6
Aromatics: C_8 - C_{10}	NA	NA	CONCAWE (1996)	Basic approach from CONCAWE (1996); specific TRV calculations and rationale given in Appendix A.	NA	212

a Contaminants of potential concern (COPCs) are based on the updated SLERA conducted by EPA (2008a).

b Ambient Water Quality Criteria (AWQC) are from EPA (2006a). Tier II and lowest chronic values (LCV) are from Suter and Tsao (1996). Oregon Department of Environmental Quality (DEQ) values are from DEQ (2006). PAH mixture values are from EPA (2003). MacDonald et al. (1999) are from Environment Canada, Georgia Basin Action Plan compendium of environmental quality benchmarks. ECOTOX values were based on EPA's online toxicity database, ECOTOX (EPA 2007a). Other supporting references include EPA sediment quality guideline development (EPA 1993), EPA Office of Solid Waste and Emergency Response ecotoxicity thresholds (OSWER 1996), and CONCAWE hydrocarbon block method guidance (CONCAWE 1996).

c Chronic AWQC for total PCBs are based on a final residue value for protection of aquatic life uses (human health consumption), not the protection of aquatic life itself. Suter and Tsao (1996) calculated a secondary chronic value for protection of aquatic life of 0.14 µg/L. However, the AWQC-based value was selected here because DEQ uses this value for aquatic life protection in their proposed water quality standards (Table 33A).

AWQC – ambient water quality criteria
Eco-SL – ecological screening level
EPA – US Environmental Protection Agency
DEQ – Oregon Department of Environmental Quality
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl

LCV – lowest chronic value
LC50 – dose that is lethal to 50% of an exposed population
LC100 – dose that is lethal to 100% of an exposed population
NA – not available
SL – screening level
TCDD – tetrachlorodibenzo-*p*-dioxin
TPH – total petroleum hydrocarbons
TRV – toxicity reference value

Table 2. Fish Dietary Dose TRVs from Round 2 Report and as Proposed for BERA

Analyte	Units	Round 2 Report (February 2007)		Round 2 Report Source and Notes	Proposed for BERA		Notes
		NOAEL	LOAEL		NOAEL	LOAEL	
Cadmium	mg/kg bw/day	0.002	0.01	Kim et al. (2004); Kang et al. (2005)	0.002	0.01	No changes recommended.
Copper	mg/kg bw/day	0.24	0.48	Murai et al. (1981)	0.24	0.48	No changes recommended. Values consistent with Clearwater et al. (2002) review paper.
Mercury	mg/kg bw/day	0.013	0.048	Matta et al. (2001)	0.005	0.013	The NOAEL of 0.013 mg/kg/d in the Round 2 Report is based on a dietary NOEC of 0.5 mg/kg and an assumed FIR of 2.5%. The dietary MeHg concentration of 0.5 mg/kg, however, was associated with statistically significant ($p<0.05$) mortality in male fish (47.7% mortality vs. 0% mortality in the controls). The true NOEC from the study would be 0.2 mg/kg, or a NOAEL of 0.005 mg/kg/d.
TBT	mg/kg bw/day	0.0021	0.20	Shimasaki et al. (2003)	0.00042 (UF of 5)	0.0021	The NOAEL of 0.0021 mg/kg/d in the Round 2 Report is based on a dietary NOEC of 0.1 mg/kg. At this dietary concentration, growth (weight) was significantly ($p<0.05$) reduced by 35% after 100 days on the TBT diet and the proportion of sex-reversed males was significantly ($p<0.05$) greater (25.7% vs. 2.2% in controls). The LWG considered this a NOEC because growth recovered by day 300 and due to uncertainties in the sex reversal endpoint. Regardless of uncertainties in the latter, the growth recovered by day 300 because fish were put back on the control diet at day 100. A 35% growth reduction by day 100 is a significant effect and there is no reason to suspect that fish would have recovered this weight loss if continued on the TBT diet for the next 200 days.
Benzo(a)pyrene	mg/kg bw/day	0.66	1.4	Rice et al. (2000)	0.66	1.4	No changes recommended.
Total PAHs	mg/kg bw/day	6.1	18	Meador et. al. (2006)	6.1	18	No changes recommended.
Total PCBs	mg/kg bw/day	0.01	0.05	Hugla and Thome (1999)	0.01	0.05	No changes recommended.
Total DDTs	mg/kg bw/day	0.028	0.14	Macek (1968)	0.028	0.14	No changes recommended.

Table 3. Bird Dietary Dose TRVs from Round 2 Report and as Proposed for BERA

Analyte	Units	Round 2 Report (February 2007)		Round 2 Report Source and Notes	Proposed for BERA		Notes
		NOAEL	LOAEL		NOAEL	LOAEL	
Arsenic	mg/kg bw/day	2.3	6.8	USFWS (1969) as cited in Sample et al. (1996)	2.24	4.50	**ECO SSL, Arsenic (EPA 2005b)**. The ECO SSL TRV is based on the lowest NOAEL value for effects on reproduction, growth or survival. There were not enough data to calculate a geometric mean, nor any matched NOAELs and LOAELs. The lowest LOAEL was lower than the NOAEL TRV, so a geometric mean of the available LOAELs was used for this TRV rather than selecting a single study or using an uncertainty factor.
Cadmium	mg/kg bw/day	0.73	2.9	Leach et al. (1979)	1.47	6.34	**ECO-SSL, Cadmium (EPA 2005c)**. The ECO SSL TRV was based on the geometric mean of NOAELs for reproduction and growth. A geometric mean of LOAELs was calculated using the same data.
Chromium	mg/kg bw/day	1	5	Haseltine et al. as cited in Sample (1996)	2.66	15.6	**ECO-SSL, Chromium (EPA 2005d)**. The ECO SSL was based on the geometric mean of NOAELs for reproduction and growth and is higher than the lowest bounded LOAEL within the reproduction, growth, and survival effect groups. A geometric mean of LOAELs was calculated using the same data.
Copper	mg/kg bw/day	47	62	Mehring et al. (1960)	4.05	12.1	**ECO-SSL, Copper (EPA 2007b)**. The ECO SSL TRV, 4.05 mg copper/kg bw/day, was based on the highest NOAEL value lower than the lowest bound LOAEL for effects on reproduction, growth or survival. The LOAEL was selected from the same study as the NOAEL.
Lead	mg/kg bw/day	2	20	Edens and Garlich (1983)	1.63	3.26	**ECO-SSL, Lead (EPA 2005e)**. The ECO SSL TRV was based on the NOAEL for lead, 1.63 mg lead/kg bw/day, which is the highest bounded NOAEL below the lowest bounded LOAEL for effects on growth, reproduction, or survival. The LOAEL was selected from the same study as the NOAEL.

Table 3. Bird Dietary Dose TRVs from Round 2 Report and as Proposed for BERA (Continued)

Analyte	Units	Round 2 Report (February 2007)		Round 2 Report Source and Notes	Proposed for BERA		Notes
		NOAEL	LOAEL		NOAEL	LOAEL	
Selenium	mg/kg bw/day	0.42	0.82	Heinz et al. (1989)	0.29	0.579	**ECO-SSL, Selenium (EPA 2007d)**. The ECO SSL TRV is the highest NOAEL value lower than the lowest bounded LOAEL value for effects on reproduction, growth or survival. The LOAEL was selected from the same study as the NOAEL.
Thallium	mg/kg bw/day	0.48	24	Hudson et al. (1984)	0.48	24	**Hudson et al. (1984).** No change recommended.
Zinc	mg/kg bw/day	8.2	124	Roberson and Schaible (1960)	66.1	171	**ECO-SSL, Zinc (EPA 2007f)**. The ECO SSL TRV is based on the geometric mean of NOAEL values for effects on reproduction and growth. A geometric mean of LOAELs was calculated using the same data.
Mercury	mg/kg bw/day	0.01	0.05	Heinz et al. (1975, 1979)	0.0064	0.064	**Sample et al. (1996)** calculation from Heinz (1979). As cited by Sample et al. (1996), fewer eggs and ducklings were produced at the LOAEL.
TBT	mg/kg bw/day	1.4	3.6	Schlatterer et al. (1993); Coenen et al. (1992)	6.8	16.9	**Schlatterer et al. (1993).** As cited by Sample et al. (1996), egg weight and hatchability were reduced at this LOAEL.
Benzo(a)pyrene	mg/kg bw/day	0.28	1.4	Hough et al. (1993)	0.28	1.4	**Hough et al. (1993)**. No change recommended.
Total PAHs	mg/kg bw/day	40	NA	Patton and Dieter (1980)	40	NA	**Patton and Dieter (1980)**. No change recommended.
bis(2-ethylhexyl) phthalate	mg/kg bw/day	1.45	329	Peakall (1974); Ishida et al. (1982)	1.1	11	**Sample et al. (1996)** calculation for Peakall (1974). No significant reproductive effects were observed among doves on diets at the NOAEL (only dose tested). LOAEL estimated using a 10X uncertainty factor as in SREL (1999).
Di-n-butyl phthalate	mg/kg bw/day	1.45	329	Assumed same as BEHP	0.11	1.1	**Sample et al. (1996)**. Eggshell thickness and water permeability of the shell were reduced among doves at the LOAEL.
PCB TEQ	mg/kg bw/day	1.4 x 10-5	1.4 x 10-4	Nosek et al. (1992)	1.4 x 10-5	1.4 x 10-4	**Nosek et al. (1992)**. No change recommended.

Table 3. Bird Dietary Dose TRVs from Round 2 Report and as Proposed for BERA (Continued)

Analyte	Units	Round 2 Report (February 2007)		Round 2 Report Source and Notes	Proposed for BERA		Notes
		NOAEL	LOAEL		NOAEL	LOAEL	
Total PCBs	mg/kg bw/day	0.29	0.58	Britton and Huston (1973)	0.29	0.58	**Britton and Huston (1973)**. No change recommended.
Dioxin TEQ	mg/kg bw/day	1.4 x 10-5	1.4 x 10-4	Nosek et al. (1992)	1.4 x 10-5	1.4 x 10-4	**Nosek et al. (1992)**. No change recommended.
Total DDTs	mg/kg bw/day	0.18	1.8	Davison and Sell (1974)	0.227	2.27	**ECO-SSL, DDT (EPA 2007b)**. The ECO SSL TRV (NOAEL) for DDT and its metabolites is 0.227 mg DDT/kg bw/day, which is the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction, growth or survival. The LOAEL was selected from the same study as the NOAEL.
Sum DDD	mg/kg bw/day	0.18	0.9	Heath et al. (1969)	NA	NA	**ECO-SSL, DDT (EPA 2007b)**. The ECO SSL TRV for DDT is not metabolite specific, so no separate TRV for DDD is necessary.
Sum DDE	mg/kg bw/day	0.064	0.32	Mendenhall et al. (1983) barn owl study; UF of 5 used to extrapolate from LOAEL to NOAEL.	0.032	0.32	**Mendenhall et al. (1983)** as per previous EPA comments to use the barn owl study, but with a UF of 10 to estimate the NOAEL. Even though the ECO SSL TRV is to be applied to DDT and its metabolites, a separate TRV for DDE is still needed to reflect the differential sensitivity and response of birds to this specific metabolite.
Sum DDT	mg/kg bw/day	0.03	0.15	Stickel and Rhodes (1970)	NA	NA	**ECO-SSL, DDT (EPA 2007b)**. The ECO SSL TRV for DDT is not metabolite specific, so no separate TRV for sum DDTs is necessary.
Aldrin	mg/kg bw/day	0.008	0.04	DeWitt (1956)	0.008	0.04	**DeWitt (1956)**. No change recommended.

Table 4. Mammal Dietary Dose TRVs from Round 2 Report and as Proposed for BERA

Analyte	Units	Round 2 Report (February 2007)		Round 2 Report Source and Notes	Proposed for BERA		Notes
		NOAEL	LOAEL		NOAEL	LOAEL	
Antimony	mg/kg bw/day	149	NA	Hext et al. (1999)	0.059	0.59	**ECO-SSL, Antimony (EPA 2005a)**. The ECO SSL TRV for antimony is equal to 0.059 mg antimony/kg BW/day, which is the highest bounded NOAEL below the lowest bounded LOAEL for effects on reproduction, growth or survival. The LOAEL was selected from the same study as the NOAEL.
Copper	mg/kg bw/day	18	26	Aulerich et al. (1982)	5.6	9.34	**ECO-SSL, Copper (EPA 2007b)**. The ECO SSL TRV for copper is 5.60 mg copper/kg bw/day, which is the highest NOAEL value lower than the lowest LOAEL value for reproduction and growth. The LOAEL was selected from the same study as the NOAEL.
Lead	mg/kg bw/day	11	90	Azar et al. (1973)	4.7	8.9	**ECO-SSL, Lead (EPA 2005e)**. The ECO SSL TRV for lead is 4.70 mg lead/kg bw/day, which is the highest bounded NOAEL below the lowest bounded LOAEL for results in the growth, reproduction, and survival effect groups. The LOAEL was selected from the same study as the NOAEL.
Selenium	mg/kg bw/day	0.055	0.08	Halverson et al. (1966)	0.143	0.215	**ECO-SSL, Selenium (EPA 2007d)**. The ECO SSL TRV for selenium is 0.143 mg selenium/kg bw/day, which is the highest NOAEL value lower than the lowest LOAEL value for reproduction and growth. The LOAEL was selected from the same study as the NOAEL.
Mercury	mg/kg bw/day	0.02	0.07	Dansereau et al. (1999)	0.02	0.07	**Dansereau et al. (1999).** No change recommended.

Table 4. Mammal Dietary Dose TRVs from Round 2 Report and as Proposed for BERA (Continued)

Analyte	Units	Round 2 Report (February 2007)		Round 2 Report Source and Notes	Proposed for BERA		Notes
		NOAEL	LOAEL		NOAEL	LOAEL	
Total PAHs	mg/kg bw/day	NA	10	MacKenzie and Angevine (1981)	NA	NA	EPA recommends using separate low molecular weight and high molecular weight PAH TRVs as was done in ECO SSL (EPA 2007d).
LMW PAHs	mg/kg bw/day				65.6	328	**ECO SSL PAH (EPA 2007e)**. The ECO SSL TRV for LMW - PAHs is 65.6 mg/kg bw/day, which is the highest bounded NOAEL lower than the lowest bounded LOAEL value for reproduction, growth or survival. The LOAEL was selected from the same study as the NOAEL.
HMW PAHs	mg/kg bw/day				0.615	3.07	**ECO SSL PAH (EPA 2007e)**. The ECO SSL TRV for high molecular weight PAHs is 0.615 mg/kg bw/day, which is the highest bounded NOAEL lower than the lowest bounded LOAEL value for reproduction, growth or survival. The LOAEL was selected from the same study as the NOAEL.
PCB TEQ	mg/kg bw/day	2.2 x 10-7	2.2 x 10-6	Tillitt et al. (1996)	2.2 x 10-7	2.2 x 10-6	EPA continues to recommend use of the **Tillitt et al. (1996)** TRVs for PCB and dioxin TEQs. While we recognize there are uncertainties in the use of field-collected carp as a diet source, the carp tissues were well-characterized chemically, and most contaminants other than PCBs and dioxins were present at concentrations below those known to induce adverse impacts, and the specific effects observed in mink were characteristic of PCB and dioxin. Both PCB and dioxin TEQs should be considered as a single total using appropriate TEFs.
Total PCBs	mg/kg bw/day	0.0074	0.037	Restum et al. (1998)	0.0074	0.037	**Restum et al. (1998)**. No change recommended.

Table 4. Mammal Dietary Dose TRVs from Round 2 Report and as Proposed for BERA (Continued)

Analyte	Units	Round 2 Report (February 2007)		Round 2 Report Source and Notes	Proposed for BERA		Notes
		NOAEL	LOAEL		NOAEL	LOAEL	
Dioxin TEQ	mg/kg bw/day	2.2 x 10-7	2.2 x 10-6	Tillitt et al. (1996)	2.2 x 10-7	2.2 x 10-6	EPA continues to recommend use of the **Tillitt et al. (1996)** TRVs for PCB and dioxin TEQs. While we recognize there are uncertainties in the use of field-collected carp as a diet source, the carp tissues were well-characterized chemically, and most contaminants other than PCBs and dioxins were present at concentrations below those known to induce adverse impacts, and the specific effects observed in mink were characteristic of PCB and dioxin. Both PCB and dioxin TEQs should be considered as a single total using appropriate TEFs.
Total DDTs	mg/kg bw/day	1.2	1.3	Duby et al. (1971) Virgo and Bellward (1977)	0.147	0.735	**ECO-SSL, DDT (EPA 2007c)**. The ECO SSL for DDT (and its metabolites) is 0.147 mg DDT/kg bw/day, which is the highest bounded NOAEL lower than the lowest bounded LOAEL value for reproduction, growth or survival. The LOAEL was selected from the same study as the NOAEL.

Table 5. Sediment TRVs Proposed for BERA

Chemical of Potential Concern[a]	Units	SQGs: Consensus-based PEC	SQGs: Mechanistic-based EqP-based[b]	SQGs: Empirical PEL	SQGs: Empirical CSL[c]	SQGs: Empirical JSCS	Surface COPC	Sub-surface COPC	EPA-Recommended Chronic Water TRV (µg/L)	Source[d]	K_{oc}	Source[e]
Metals												
Arsenic	mg/kg	33	-	17	93	33(1)	X	X	150	AWQC	-	-
Cadmium	mg/kg	4.98	-	3.53	6.7	4.98(1)	X	X	0.09	AWQC	-	-
Chromium, total	mg/kg	111	-	90	270	111(1)	X	X	23.8	AWQC	-	-
Copper	mg/kg	149	-	197	390	149(1)	X	X	2.74	AWQC	-	-
Lead	mg/kg	128	-	91.3	530	128(1)	X	X	0.54	AWQC	-	-
Manganese	mg/kg	-	-	-	-	1,100(2,3)	X		120	Tier II	-	-
Mercury	mg/kg	1.06	-	0.49	0.59	1.06(1)	X	X	0.77	AWQC	-	-
Nickel	mg/kg	48.6	-	35.9	-	48.6(1)	X	X	16.1	AWQC	-	-
Selenium	mg/kg	-	-	-	-	5(4)	X	X	5	AWQC	-	-
Silver	mg/kg	-	-	-	6.1	5(4,5)	X		0.1	DEQ	-	-
Zinc	mg/kg	459	-	315	960	459(1)	X	X	36.5	AWQC	-	-
PAHs												
2-Methylnaphthalene	µg/kg	-	9,093	201**	64,000	200(6)	X	X	2.1	Tier II	4,330	Mean; Kenaga 1980, Duxbury 1988, Montgomery and Welkom 1990.
Acenaphthene	µg/kg	-	105,800	88.9**	57,000	300(2)	X	X	23	Tier II	4,600	EPA 1986
Acenaphthylene	µg/kg	-	1,061,615	128**	66,000	200(2)	X	X	306.9	EPA 2003	3,459	Mean; EPA 1986, Montgomery and Welkom 1990.
Anthracene	µg/kg	845	3,0364	245**	1,200,000	845(1)	X	X	0.73	Tier II	41,594	Mean; Duxbury 1988, EPA 1986.
Benzo(a)anthracene	µg/kg	1,050	1,123	385	270,000	1,050(1)	X	X	0.027	Tier II	41,594	Mean; Duxbury 1988, EPA 1986.
Benzo(a)pyrene	µg/kg	1,450	100,508	782	210,000	1,450(1)	X	X	0.014	Tier II	7,179,142	Mean; Duxbury 1988, EPA 1986.
Benzo(g,h,i)perylene	µg/kg	-	702,560	-	78,000	300(7)	X	X	0.4391	EPA 2003	1,600,000	EPA 1986
Benzo(k)fluoranthene	µg/kg	-	352,825	-	-	13,000(2)	X	X	0.6415	EPA 2003	550,000	EPA 1986
Benzofluoranthenes, total	µg/kg	-	-	-	450,000	-	X	No data - not evaluated	-	-	-	-

Table 5. Sediment TRVs Proposed for BERA (Continued)

Chemical of Potential Concern[a]	Units	SQGs: Consensus-based PEC	SQGs: Mechanistic-based EqP-based[b]	SQGs: Empirical PEL	SQGs: Empirical CSL[c]	SQGs: Empirical JSCS	Surface COPC	Sub-surface COPC	EPA-Recommended Chronic Water TRV (µg/L)	Source[d]	K_{oc}	Source[e]
Chrysene	µg/kg	1,290	626,709	862	460,000	1,290(1)	X	X	2.042	EPA 2003	306,909	Mean; EPA 1986, Montgomery and Welkom 1990, Duxbury 1988.
Dibenzo(a,h)anthracene	µg/kg	-	500,226	135**	33,000	1,300(3)	X	X	0.2825	EPA 2003	1,770,712	Mean; EPA 1986, Montgomery and Welkom 1990, Duxbury 1988.
Fluoranthene	µg/kg	2,230	1,257,711	2,355	1,200,000	2,230(1)	X	X	6.16	Tier II	204,174	Duxbury, 1988
Fluorene	µg/kg	536	3,3707	144**	79,000	536(1)	X	X	3.9	Tier II	8,643	Mean; EPA 1986, Duxbury 1988.
Indeno(1,2,3-c,d)pyrene	µg/kg	-	1,933,716	-	88,000	100(8)	X	X	0.275	EPA 2003	7,031,694	Mean; EPA 1986, Montgomery and Welkom 1990.
Naphthalene	µg/kg	561	37,126	391**	170,000	561(1)	X	X	12	Tier II	3,094	Mean; Kenaga 1980, Duxbury 1988.
PAHs, total	µg/kg	22,800	-	-	-	-	X	X	-	-	-	-
PAHs, total high molecular weight PAHs	µg/kg	-	-	-	5,300,000	-	X	X	-	-	-	-
PAHs, total low molecular weight PAHs	µg/kg	-	-	-	780,000	-	X	X	-	-	-	-
Phenanthrene	µg/kg	1,170	108,719	515	480,000	1,170(1)	X	X	6.3	Tier II	17,257	Mean; Kenaga 1980, EPA 1986, Duxbury 1988.
Pyrene	µg/kg	1,520	706,117	875	1,400,000	1,520(1)	X	X	10.11	EPA 2003	69,843	Mean; EPA 1986, Duxbury 1988.
Pesticides/PCBs												
Aldrin	µg/kg	-	2,727	-	-	40(2)	X	X	0.3	MacDonald et al. 1999	9,090	Mean; Kenaga 1980, Duxbury 1988.
Aroclor 1016	µg/kg	-	644	-	-	530(3)	X*	X*	0.014	MacDonald et al. 1999	46,000	Lyman et al. 1990
Aroclor 1248	µg/kg	-	3,726	-	-	1,500(3)	X	X	0.081	Tier II	46,000	Lyman et al. 1990
Aroclor 1254	µg/kg	-	37,790	340**	-	300(3)	X	X	0.033	Tier II	1,145,151	Mean; Kenaga 1980, Duxbury 1988.
Aroclor 1260	µg/kg	-	4,324,022	-	-	200(3)	X	X	94	Tier II	46,000	Lyman et al. 1990
Chlordane (cis & trans)	µg/kg	17.6	615	8.9	-	17.6(1)	X	X*	0.0043	AWQC	143,013	Mean; EPA 1986, Montgomery and Welkom 1990.
DDTs, sum of p,p'-DDD and o,p'-DDD	µg/kg	28	-	-	-	28(1)	X	X	-	-	-	-
DDTs, sum of p,p'-DDE and o,p'-DDE	µg/kg	31.3	-	-	-	31.3(1)	X	X	-	-	-	-
DDTs, sum of p,p'-DDT and o,p'-DDT	µg/kg	62.9	-	-	-	62.9(1)	X	X	-	-	-	-
DDTs, total of 6 isomers	µg/kg	572	-	4,450	-	-	X	X	0.001	AWQC	-	-
Dieldrin	µg/kg	61.8	234	6.67	-	61.8(1)	X	X	0.056	AWQC	4,170	Mean; EPA 1986, Duxbury 1988.
Endrin	µg/kg	207	61	62.4	-	207(1)	X	X	0.036	AWQC	1,698	Duxbury 1988

Table 5. Sediment TRVs Proposed for BERA (Continued)

		SQGs										
		Consensus-based	Mechanistic-based	Empirical								
Chemical of Potential Concern[a]	**Units**	**PEC**	**EqP-based[b]**	**PEL**	**CSL[c]**	**JSCS**	**Surface COPC**	**Sub-surface COPC**	**EPA-Recommended Chronic Water TRV (µg/L)**	**Source[d]**	**K_{oc}**	**Source[e]**
Heptachlor	µg/kg	-	42	-	-	10[(2)]	X*	X	0.0038	AWQC	10,954	Mean; EPA 1986, Duxbury 1988.
Heptachlor epoxide	µg/kg	16	1	2.74	-	16[(1)]	X	X	0.0038	AWQC	220	EPA 1986
Hexachlorobenzene	µg/kg	-	30,646	-	2,300	100[(2)]	X	X	3.68	MacDonald et al. 1999	8,328	Mean; EPA 1986, Duxbury 1988.
Hexachlorocyclohexane-gamma	µg/kg	4.99	77	1.38	-	4.99	X	X	0.08	DEQ	965	Mean; Kenaga 1980, EPA 1986, Duxbury 1988.
Hexachlorocyclopentadiene	µg/kg	-	38	-	-	400[(9)]	X*	X*	0.008	MacDonald et al. 1999	4,800	EPA 1986
p,p'-DDD	µg/kg	-	430	8.51	-	-	X	X	0.001	AWQC	429,779	Mean; EPA 1986, Duxbury 1988.
p,p'-DDE	µg/kg	-	807	6.75	-	-	X	X	0.001	AWQC	806,742	Mean; EPA 1986, Duxbury 1988.
PCBs, total (calc)	µg/kg	676	-	277	65,000	676[(1)]	X	X	0.014	DEQ 33A and AWQC	-	-
SVOL												
1,2,4-Trichlorobenzene	µg/kg	-	1,012,000	-	1,800	9,200[(10)]	X	X	110	Tier II	9,200	EPA 1986
1,2-Dichlorobenzene	µg/kg	-	23,800	-	2,300	1,700[(10)]	X	X	14	Tier II	1,700	EPA 1986
1,3-Dichlorobenzene	µg/kg	-	120,700	-	-	300[(10)]	X*	X*	71	Tier II	1,700	EPA 1986
1,4-Dichlorobenzene	µg/kg	-	25,500	-	9,000	300[(10)]	X	X	15	Tier II	1,700	EPA 1986
2,4-Dimethylphenol	µg/kg	-	1,156	-	29	-	X	X*	2.4	MacDonald et al. 1999	482	Lyman et al. 1990
2-Methylphenol	µg/kg	-	284	-	63	-	X	X*	13	Tier II	22	Montgomery and Welkom 1990
4-Methylphenol	µg/kg	-	-	-	670	-	X	X	-	-	49	Montgomery and Welkom 1990
Benzoic acid	µg/kg	-	704	-	650	-	X	X	42	Tier II	17	Lyman et al. 1990
Benzyl alcohol	µg/kg	-	788	-	73	-	X	X	8.6	Tier II	92	Lyman et al. 1990
Bis(2-ethylhexyl)phthalate	µg/kg	-	300,000	-	78,000	800[(2,5)]	X	X	3	Tier II	100,000	Montgomery and Welkom 1990
Butylbenzyl phthalate	µg/kg	-	31,278	-	64,000	-	X	X	3	Tier II	10,426	Lyman et al. 1990
Carbazole	µg/kg	-	-	-	-	1,600[(5)]	X	X	18.6	Brooke 1991	2,516	Lyman et al. 1990
Diethyl phthalate	µg/kg	-	426	-	110,000	600[(10)]	X*		3	Tier II	142	EPA 1986
Dimethyl phthalate	µg/kg	-	132	-	53,000	-	X*		3	Tier II	44	Kenaga 1980
Di-N-octyl phthalate	µg/kg	-	3,323,849	-	4,500,000	-	X	X	3	Tier II	1,107,950	Lyman et al. 1990

Table 5. Sediment TRVs Proposed for BERA (Continued)

		SQGs										
		Consensus-based	Mechanistic-based	Empirical					EPA-Recommended Chronic Water TRV (µg/L)			
Chemical of Potential Concern[a]	**Units**	**PEC**	**EqP-based[b]**	**PEL**	**CSL[c]**	**JSCS**	**Surface COPC**	**Sub-surface COPC**		**Source[d]**	**K_{oc}**	**Source[e]**
Hexachlorobutadiene	µg/kg	-	37,700	-	6,200	600(9)	X	X	1.3	Canadian EQG	29,000	EPA 1986
N-nitrosodiphenylamine	µg/kg	-	252,313	-	11,000	-	X	X	210	Tier II	1,201	Lyman et al. 1990
Pentachlorophenol	µg/kg	-	103,598	-	690	1,000(9)	X	X	15	AWQC	6,907	Mean; Kenaga 1980, EPA 1986.
Phenol	µg/kg	-	2,489	-	1,200	50(2,5)	X	X*	110	Tier II	23	Mean; Kenaga 1980, EPA 1986, Duxbury 1988.
Tetrachloroethene	µg/kg	-	30,323	-	-	500(10)		X*	98	Tier II	309	Mean; EPA 1986, Abdul et al. 1987.
Trichloroethene	µg/kg	-	4,239	-	-	2,100(10)		X	47	Tier II	90	Mean; EPA 1986, Abdul et al. 1987.
Dioxins/Furans												
Dibenzofuran	µg/kg	-	46,580	-	58,000	-	X	X	3.7	Tier II	12,589	Montgomery and Welkom 1990
2,3,7,8-TCDD (Dioxin)	µg/kg	-	39	-	-	0.009(2)	X	X	0.00001	AWQC	3,883,801	Mean; EPA 1986, Montgomery and Welkom 1990.

[a] Chemicals of Potential Concern (COPCs) are based on the updated SLERA Sediment Quality Guideline (SQG) screen conducted by EPA (2008a).

[b] EqP-based values are expressed on an organic carbon normalized basis.

[c] CSL values are expressed on an organic carbon normalized basis for all analytes except all metals, phenol, 2-methylphenol, 4-methylphenol, 2,4,-dimethylphenol, pentachlorophenol, benzyl alcohol, and benzoic acid.

[d] Ambient Water Quality Criteria (AWQC) are from EPA (2006a). Tier II are from Suter and Tsao (1996). Oregon Department of Environmental Quality (DEQ) values are from DEQ (2006) Tables 33A or 33b only. PAH mixture values are from EPA (2003). Canadian EQG are from Canadian Water Quality Guidelines updated in 2007 (CCME 2007). MacDonald et al. (1999) are from Environment Canada, Georgia Basin Action Plan compendium of environmental quality benchmarks.

[e] All K_{oc}s from Lyman et al. 1980 were calculated based on K_{ow} values using the following equation: Log K_oc =(0.544 * Log K_{ow} + 1.377). Mean values are average K_{oc}s from the mulitple sources listed.

* Based on non-detected values exceeding SQG only (i.e. ½ DL > SQG)

- : Not Available

PEC: Consensus-Based Freshwater Probable Effect Concentrations (MacDonald et al. 2000) (FWCONPEC in Query Manager).

**PEL: Threshold Effect Level, freshwater (Smith et al. 1996) (PELFW in Query Manager) except values with **, which are from CCME 2002.

CSL: Washington State Cleanup Screening Levels and Minimum Cleanup Levels (Washington State Department of Ecology 1995) (WA_CSL95 in Query Manager).

Eq-P based: Equilibrium Partitioning-Based Sediment Benchmarks (EPA 2008b).

JSCS: Joint Source Control Strategy (DEQ 2007), Table 3-1 (07/16/07 Revision).

(1) These values were taken MacDonald DD, Ingersoll C.G., Berger T.A. (2000) Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems. Environmental Contamination and Toxicity 39: 20-31.

(2) Upper Effects Threshold (UET), Freshwater Sediment (NOAA, 1999).

(3) Severe effect level, British Columbia, quoted in MacDonald et al. (1999); Appendix 3-1.

(4) Quoted in MacDonald et al. (1999); Appendix 3-1.

(5) Lowest Apparent Effects Threshold (LAET), Table 11, WDOE (1997).

(6) PEL, British Columbia, quoted in MacDonald et al. (1999); Appendix 3-1.

(7) Values were taken from Table 33c (OAR 340-41), which are Water Quality Guidance Values, not criteria, that can be used in the application of Oregon's Narrative Toxics Criteria to waters of the state in order to protect aquatic life.

(8) 5x conversion from measured "LOW" to estimated "HIGH", NOAEL to chronic LOAEL per USEPA (1997b).

(9) New York State acute criterion, quoted in MacDonald et al. (1999); Appendix 3-1.

(10) USEPA sediment quality advisory level, quoted in MacDonald et al. (1999); Appendix 3-1.

Calculation of Aquatic Biota Toxicity Reference Values (TRVs) for Petroleum Alkanes, Alkenes, Cycloalkanes, BTEX and PAH Compounds

Total Petroleum Hydrocarbon (TPH) Mixture TRV Derivation

We are unaware of any promulgated ecological screening level toxicity reference values (TRVs) for total petroleum hydrocarbon mixtures. The only efforts to date to derive TPH TRVs (Michelsen 1997, URS 1996c, Golder Associates 1995) have all utilized a tissue residue approach. These three efforts, performed originally for sites in Washington, Alaska and British Columbia, respectively, have more similarities than differences in their methodologies. All are limited to some extent by the amount of residue-effects literature for individual components of TPH mixtures, and by publicly available petroleum mixture toxicity data in the scientific literature.

The tissue residue approach starts with a critical body residue of a toxicant, then in essence runs a bioaccumulation model backwards to calculate the maximum chemical concentration in water or sediment which does not result in exceedance of the critical body residue (CBR). These maximum media concentrations which do not result in exceedance of a CBR are the TRVs used to evaluate ecological risks from media concentrations of TPH mixtures.

The original derivation of ecological TRVs for TPH mixtures was based on State of Alaska definitions of three TPH fractions: gasoline range organics (alkanes, alkenes, cycloalkanes and BTEX with a carbon chain length between C_6 and C_{10}), diesel range organics (C_{10} to C_{25}) and residual range organics ($>C_{25}$). Most of this discussion is based on the Alaska defined TPH fractions.

A strength of the TRV derivation methodology discussed in this paper is that the procedure is adaptable to any number of defined TPH fractions. TRVs will also be derived herein for State of Oregon's 12 defined TPH fractions, seven of which are aliphatic fractions (C_5 to C_6, C_6 to C_8, C_8 to C_{10}, C_{10} to C_{12}, C_{12} to C_{16}, C_{16} to C_{21}, and C_{21} to C_{34}), five of which are aromatic fractions (C_8 to C_{10}, C_{10} to C_{12}, C_{12} to C_{16}, C_{16} to C_{21}, and C_{21} to C_{34}).

Petroleum alkanes, alkenes and cycloalkanes are considered to elicit their toxicity to aquatic life by a mode of toxic action termed narcosis (CONCAWE 2001, Schultz 1997, Snyder 1987). Many aromatic compounds in petroleum, such as the BTEX chemicals, also elicit toxicity to aquatic life via narcosis. Short-term PAH toxicity to many aquatic species, particularly invertebrates with poor metabolic transformation capabilities for organic chemicals, is also due to narcotic toxicity (DiToro et al. 2000). Narcotic chemicals do not have a specific site or organ in the body where they elicit their toxicity. Instead, they are believed to elicit their toxic effects after dissolution of the chemical in the lipid layer of membranes, resulting in an increased volume fraction of the chemical in tissue and disruption of cellular function (Franks and Lieb 1978). Symptoms of narcotic toxicity include decreased nervous system activity, lethargy, loss of equilibrium and ultimately death. Narcotic toxicity is reversible if the environmental concentration of the

chemical is reduced below that required to elicit toxicity. Narcosis is perhaps better known as the mode of toxic action of anaesthetics used in medicine.

As is the case with nearly all chemicals, narcotic chemicals must first be accumulated in the tissues of an aquatic species to a concentration which elicits the toxic response. Toxicity does not occur until the chemical concentration in tissues exceeds a critical body residue. Critical body residues in a number of aquatic species for a number of narcotic chemicals have been measured. These studies (summarized in McCarty and Mackay 1993, Van Wezel and Opperhuizen 1995, Escher and Hermens 2002) have observed that when expressed on a molar concentration basis, the critical body residue of narcotic chemicals associated with mortality is constant within a narrow range centered on 2 - 8 millimoles per kilogram (mmol/kg) whole body, wet weight. Limited information is available regarding narcotic chemical residues associated with chronic toxicity, defined here as any adverse effect other than mortality. What information is available indicates that chronic narcotic toxicity begins to occur at tissue residues approximately an order of magnitude lower (0.2 - 0.8 mmol/kg) than the lethal body burden of 2 - 8 mmol/kg. A database of tissue residues associated with adverse toxic effects in aquatic biota (Bridges and Lutz 1999, Shephard 1998) contains some information on petroleum alkane residues associated with toxicity. The data indicates that alkane toxicity begins to occur at around 0.24 mmol/kg, within the range of critical body residues predicted to be associated with chronic toxicity. Table 6 provides a summary of the residue-effects literature for alkanes and BTEX chemicals in aquatic biota.

Narcotic toxicity is often referred to as "baseline toxicity", as narcosis corresponds to the minimal level of toxicity exerted by any chemical. Chemicals with specific modes of toxic action are more toxic (i.e. require lower body burdens to elicit toxicity) than would be expected on the basis of narcotic toxicity.

The toxicity of mixtures of narcotic chemicals has been found to be strictly concentration additive (Deneer et al. 1988, Hermens et al. 1984), implying that the composition of a mixture of narcotic chemicals causing toxicity is not important. Toxicity from a mixture of narcotic chemicals, such as petroleum alkanes, alkenes and cycloalkanes occurs when the sum of individual chemical molar concentrations of the mixture in tissue exceeds the critical body residue. This additivity of individual narcotic chemical toxicity is what permits derivation of TRVs for petroleum alkane mixtures, all of whose individual components elicit their toxicity via narcosis.

Starting with a critical body residue of petroleum alkanes (0.24 mmol/kg) believed to be a threshold for chronic toxicity, a one compartment first order kinetic (1CFOK) toxicological model (Shephard 1998) has been used to predict the concentration of alkanes in water required for an aquatic animal to bioconcentrate the critical body residue of 0.24 mmol/kg. The approach is based on the concentration of freely dissolved chemical in water. The differential equation form of the 1CFOK model used to calculate waterborne chemical concentrations of alkanes that will result in bioconcentration of 0.24 mmol/kg petroleum alkanes is given in Equation 1.

Equation 1:

$$\frac{dC_a}{dt} = (k_u \times C_W) - (k_e \times C_a)$$

where: C_a = chemical concentration in an animal (mg/kg)
t = time (hours)
C_w = chemical concentration in water (mg/L)
k_u = chemical uptake rate constant (L/kg/hour)
k_e = chemical elimination rate constant ($hour^{-1}$)

If the chemical concentration in water is assumed to be constant, Equation 1 may be exactly integrated to yield Equation 2.

Equation 2:

$$C_a = C_w \times \frac{k_u}{k_e} \times (1 - e^{-k_e t}) + (C_{a(t=0)} e^{-k_e t})$$

where all terms are defined as per Equation 1. For an animal being modeled, which has not been exposed to a chemical at the start of an experiment, $C_{a(t= 0)}$ equals zero, and the last term of Equation 2 drops out of the integrated form of the 1CFOK model. If it is assumed that the animal has been exposed to the chemical in water for a sufficiently long period to establish steady state between the chemical concentration in the animal and the water, Equation 2 reduces to Equation 3.

Equation 3:

$$C_a = C_w \times \frac{k_u}{k_e}$$

The term k_u / k_e in Equation 3 is the bioconcentration factor (BCF) of the chemical into the animal from the water, and has units of L/kg. If the animal accumulated its body burden of alkanes from multiple sources (e.g. water and diet), the term k_u / k_e becomes a bioaccumulation factor. Alkane bioaccumulation factors (Chapman and Connell 1986) for a benthic deposit feeding gastropod (*Strombus luhuanus*) were used to derive ecological TRV's for petroleum alkanes in sediment. For water, reexpressing k_u / k_e as a BCF and rearranging Equation 3 to solve for C_w yields Equation 4, which is the equation used to calculate the ecological TRV for alkanes/cycloalkanes in water.

Equation 4:

$$C_w = \frac{C_a}{BCF}$$

Bioconcentration factors for petroleum alkanes were derived from the logarithm of the octanol-water partition coefficient (log K_{OW}) of individual petroleum compounds. For TRVs which encompass a range of alkane carbon chain lengths, a log K_{OW} for the compound at the center of the range was chosen. Bioconcentration factors and log K_{OW} were related to each other using Equation 5, the regression equation used by U.S. EPA in the derivation of national ambient water quality criteria (U.S. EPA 1980).

Equation 5:

$$log\ BCF = (0.85 \times log\ K_{ow}) - 0.70$$

Compilations of log K_{OW} values for alkanes, particularly the longer carbon chain length alkanes are not readily available. Alkane log K_{OW} values were derived by combining available information from U.S. EPA and the Alaska Department of Environmental Conservation (ADEC). The derivation of the K_{ow} values for the various alkane/cycloalkane size classes starts with Equation 6, which is the regression used by the U.S. Environmental Protection Agency (1993) to convert K_{ow} values to the organic carbon-water partition coefficient (K_{OC}) needed to derive sediment quality criteria for hydrophobic organic chemicals.

Equation 6:

$$log\ K_{OC} = 0.00028 + (0.983 \times log\ K_{ow})$$

Where: K_{OC} = organic carbon - water partition coefficient

The State of Alaska (ADEC 1996) has derived Equation 7, which relates K_{OC} and carbon chain length for petroleum alkanes.

Equation 7:

$$log\ K_{OC} = (0.45 \times N_C) + 0.43$$

Where: N_C = number of carbons in the alkane (i.e. N_C = 8 for octane)

Substituting Equation 7 into Equation 6 and solving for log K_{OW} yields Equation 8, which was used to derive log K_{OW} values for determination of bioconcentration factors (Equation 5).

Equation 8:

$$\log K_{OW} = \frac{(0.45 \times N_C) + 0.43}{0.983} - 0.00028$$

Results of the TRV calculations (Equation 5) are presented in Table 7.

Some of the petroleum alkane TRVs (Table 7) at first glance appear to represent low concentrations in water. As stated earlier, the toxicological model used to derive the TRVs is based on freely dissolved chemical concentrations in water. Chemicals associated with suspended particulates are not available for uptake by biota in the model used. To compare the predicted TRVs to the maximum water solubility of the alkane fraction, Equation 9 (ADEC 1996) was used to estimate water solubility of petroleum alkanes.

Equation 9:

$$log\ S = 4.5 - (0.55 \times N_C)$$

Where: S = water solubility, mg/L

Finally, if it is desired to obtain a single TRV for two or more fractions measured in an environmental mixture, knowledge of the weight percent of the total composition of the environmental mixture each individual fraction constitutes can be used with Equation 10 to generate a TRV for multiple fractions.

Equation 10:

Using a no adverse effect tissue residue of 0.24 mmol/kg, the narcosis model predicts that alkanes with a carbon chain length greater than C_{16-17} (the actual chain length at which this occurs varies with the value of the octanol-water partition coefficient and the log K_{OW} – log BCF regression selected as starting points for the calculations) would have to exceed their maximum water solubility before any chronic toxicity could be elicited. As the narcotic toxicological model is based on the concentration of freely dissolved alkanes, the approach used to derive ecological TRV's does not apply for alkanes with carbon chain lengths greater than C_{16-17}. Toxicity of the heavier alkanes to aquatic life in the water column requires a supersaturated solution (in essence, an oil sheen, slick or spill) before toxicity would be observed.

In supersaturated solutions, toxicity is more likely to occur from physical toxicity or changes in the environment, such as suffocation or habitat degradation. These processes do not result from narcosis, thus, narcosis is not predicted to be the toxic mode of action to aquatic biota for alkanes in surface water with a carbon chain length greater than C_{16-17}. Surface water TRV's therefore have not been calculated for alkane fractions heavier than C_{16}, and for aromatic fractions in Oregon with more than 12 carbons, as the narcotic mode of toxic action is not responsible for any observed adverse effects of alkanes heavier than C_{16} or aromatics heavier than C_{12}. Any detected concentrations of diesel

range or residual range alkanes in surface waters which are greater than their maximum water solubility are assumed to represent either material surface adsorbed on particulate matter, which should have limited bioavailability and toxicity to aquatic life, or represent free product, which may pose unacceptable risks to aquatic biota. As the available analytical data do not permit a distinction between particulate sorbed and free product alkanes, any detected diesel range or residual range organics at concentrations in excess of their maximum solubility are assumed to pose potential risks to ecological receptors. Unfortunately, the potential for these toxicological risks cannot be quantified given the current state of the art. The potential for risks from supersaturated solutions of diesel range and residual range organics will be discussed in the uncertainty section of the risk assessment.

Additional details of the procedures used to derive TRVs for petroleum alkane mixtures are provided in Shephard and Webb (1998) and Shephard and McCarty (1997). Although the literature on water and sediment concentrations of petroleum alkanes associated with toxicity to aquatic life is limited, the existing data support the TRV derivation methodology used in this risk assessment. Additional support for the utility of the basic approach of this TRV development approach is found in Dyer et al. (2000), who found that TRVs, although not specifically petroleum alkane TRVs, derived by the methodology described herein overpredict adverse effects to field populations of fish. In the initial stages of risk assessment, overprediction of toxicity (i.e. a conservative risk assessment) is generally desired.

Some experimental data are available that illustrates the acute toxicity of gasoline mixtures to aquatic species. Methodological difficulties occur when testing the aquatic toxicity of sparingly soluble and volatile chemical mixtures such as petroleum hydrocarbons. These include the preparation of testing solutions, and maintaining constant concentrations of the test material during the performance of bioassays. The common adage “oil and water don’t mix” is a crude but accurate description of the difficulties in preparing test solutions of petroleum mixtures for use in toxicity testing. A chemically more accurate description of the problem is “oil is sparingly soluble in water”. Attempting to mix oil and water often results in a two phase system. A number of approaches have been historically used to prepare media for toxicity testing of petroleum mixtures, including testing of the two phase system, suspensions of petroleum maintained in solution by addition of carrier solvents, studies of water extracts of petroleum added at high mass loading rates (water soluble fraction), and removal of the water insoluble phase followed by testing of the water phase (water accommodated fraction). Open static and flow through exposure systems both permit volatilization of some petroleum fractions, making it difficult to maintain constant exposure concentrations and composition of the petroleum mixture.

Current recommendations for testing the toxicity of petroleum mixtures (CONCAWE 2001, OECD 2000) call for the use of water accommodated fraction extracts in closed systems with no head space, and under flow through or renewal conditions. Acute toxicity studies of water accommodated fractions in sealed containers with no head space evaluating mortality of aquatic species have been summarized by CONCAWE (2001).

Results from 7 species found mortality occurring at 2 – 27 mg/L (median 5.9 mg/L). Using the tissue residue approach described in this measures of effects section, the acute toxicity of gasoline, using octane (C_8H_{18}) as the surrogate alkane for the gasoline mixture results in an estimated acute toxicity range between 0.95 – 3.8 mg/L, within the lower end of the measured gasoline toxicity range. This estimate uses an estimate critical body residue of 2 – 8 mmol/kg for octane, with a molecular weight of 114.

An earlier CONCAWE (1992) literature review, evaluating gasoline toxicity of the water soluble fraction in closed containers with no head space, found the acute toxicity range for ten aquatic species to be 0.3 – 8.3 mg/L gasoline (median 3.0 mg/L). The median gasoline LC_{50} from the CONCAWE (1992) review falls within the estimated range of gasoline toxicity using the tissue residue approach in this measures of effects section. Neither CONCAWE (2001, 1992) study reports information on the chronic toxicity of gasoline. However, a literature review of non-closed system toxicity tests with TPH mixtures by Tsvetnenko (1998) identified one study (Carr and Reish 1977) that reported chronic NOEC values for reproduction of a No. 2 fuel oil on the polychaetes *Ctenodrilus serratus* and *Ophryotrocha sp*. of 0.397 and 0.301 mg/L, respectively. These chronic NOECs are 3-4 times higher than the calculated gasoline TRVs of 0.114 and 0.101 mg/L for use in Alaska and Oregon, respectively. The accuracy of the acute toxicity estimates of gasoline using the procedures in this section provide support for the use of the derived chronic LOEC TRV for gasoline.

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Table 2. Calculation of ecological toxicity reference values (TRV's) for petroleum components in water and sediment using a no effect tissue residue approach TRV development methodology.

Chemical	Surrogate Compound	Molecular Weight	Surrogate Carbon Content	BCF[a]	log BCF	log Koc[b]	log Kow[c]	---------- Toxic tissue residues ----------				Estimated maximum water solubility (µg/L)	Water TRV[f, i] µg/L	Sediment TRV mg/kg[g, j]	Sediment TRV mg/kg OC[h]
								Acute mmol/kg[d]	LOER[e] mmol/kg	Acute mg/kg	LOER mg/kg				
Alaska ecological TPH TRV's															
C_6 - C_{10} (Alaska gasoline range organics)	n-Octane	114	8	240	2.38	4.03	4.10	2	0.24	228	27.4	1259	114	12.2	1219
C_{10} - C_{25} (Alaska diesel range organics)	n-Heptadecane	240	17	764072	5.88	8.08	8.22	2	0.24	480	57.6	0.014	0.014	90.6	9063
C_{25} - C_{36} (Alaska residual range organics)	n-Hentriacontane	437	31	2.1E+11	11.33	14.38	14.63	2	0.24	874	104.9	2.8E-10	NA	1175	117476
Aliphatics (Oregon definitions)															
C_5 - C_6	n-Hexane	86.17	6	161	2.21	3.23	3.29	2	0.24	172	20.7	15849	128	2.20	220
C_6 - C_8	n-Heptane	100.203	7	447	2.65	3.72	3.78	2	0.24	200	24.0	4467	54	2.80	280
C_8 - C_{10}	n-Nonane	128.257	9	3256	3.51	4.68	4.76	2	0.24	257	30.8	355	9.5	4.52	452
C_{10} - C_{12}	n-Undecane	156.31	11	14624	4.17	5.64	5.74	2	0.24	313	37.5	28	2.6	11.3	1127
C_{12} - C_{16}	n-Tetradecane	198.4	14	4292	3.63	7.10	7.22	2	0.24	397	47.6	0.63	NA	1389	138874
C_{16} - C_{21}	n-Octadecane	254.5	18	41	1.62	9.02	9.18	2	0.24	509	61.1	0.0040	NA	NC	NC
C_{21} - C_{34}	n-Heptacosane	380.75	27	0.00081	-3.09	13.37	13.60	2	0.24	762	91.4	0.000000045	NA	NC	NC
Aromatics (Oregon definitions)															
C_8 - C_{10}	Ethylbenzene	106.2	8	120	2.08	3.10	3.15	2	0.24	212	25.5	1259	212	2.65	265
C_{10} - C_{12}	2-Methylnaphthalene	142.19	11	395	2.60	3.66	3.72	2	0.24	284	34.1	28	NA	3.93	393
C_{12} - C_{16}	Phenanthrene	178.24	14	1803	3.26	4.38	4.46	2	0.24	356	42.8	0.63	NA	5.75	575
C_{16} - C_{21}	Chrysene	228.3	18	12864	4.11	5.51	5.61	2	0.24	457	54.8	0.0040	NA	13.9	1394
C_{21} - C_{34}	Coronene	300.36	24	3783	3.58	7.16	7.28	2	0.24	601	72.1	0.0000020	NA	2732	273241

a - BCF is the bioconcentration factor, the ratio between a chemical concentration in tissue and water, L/kg
b - Koc = organic carbon-water partition coefficient
c - Kow = octanol-water partition coefficient
d - mmol/kg = millimoles/kilogram
e - LOER = Lowest Observed Effect Residue
f - TRV = Toxicity Reference Value
g - Bulk sediment TRV's in this column based on an assumed 1% organic carbon content of sediment
h - mg/kg OC = mg chemical/kg organic carbon in sediment
i - NA = Not Applicable, TRV would have to exceed maximum water solubility of these fractions
j - NC = Not Calculable, calculated TRV exceeds 100% pure surrogate compound